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A Practical Investigation on Conservation Voltage Reduction for its Efficiency with Electric Home Appliances

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Abstract

Conservation voltage reduction (CVR) method is a cost efficient solution to reduce the peak demand and power consumption. This method decreases power consumption of electric load by reducing the supply voltage. This method can be used within consumer premises to obtain more efficiency. But CVR cannot be commonly applied for all the electric home appliances. For constant power load CVR method is not suitable. So to test the efficiency of CVR under different electric home appliances, an experiment is done with commonly used electric home appliances. This experiment is done to compare and evaluate the efficiency of CVR the load power consumption values between appliances with CVR and without CVR. The results shows that majority of the home appliances reducing the power consumption with CVR method. Very few appliances tend to increases the power loss after applying CVR method. The detailed result is given in this paper. This results is used to modify the implementation process of CVR method to improve the efficiency. Results concluded that the CVR can be used for reduce the peak demand within consumer side with maintaining consumer comfort level. A new low cost smart plug design is given in this paper for implementing CVR within the consumer side.

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Keywords: Conservation Voltage Reduction; Peak Demand; Power Consumption; Energy Savings; Smart Plug; Smart Gird; Voltage Contro Method; Home Energy Management; Smart Meter; Consumer Comfort

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1. Introduction

CVR (also called as Voltage Reduction Method (VRM)) is an easy and low cost method for energy savings and peak demand reduction. CVR method reduces the power consumption by reducing the supply voltage magnitude within the allowed limit. Even though CVR method becoming familiar now a days, but it is not a new topic. CVR method proposed at the time of electricity is started to use in commercial [1]. In past, the CVR method is implemented by utilities to reduce power consumption and to reduce peak demand for maintain the availability of electric power to all of its consumers. But at present, due to latest smart grid technology and advance metering infrastructure, CVR can be implement with in consumer side [2]. Implementing CVR method has its limitation to reach the optimized level of power saving or power consumption. Not all electric home appliances reduces the power consumption, when reducing supply voltage. Some appliances may lead to more power loss. Because the efficiency of 'CVR method' is depends on the characteristic of electric appliances or load. For constant restive load, if the supply voltage is reduced then the power consumption also will reduced. But for constant power load when supply voltage is reduced then the load tends to maintain the power level so current increased which leads to higher energy losses in line [2]. This shows that the utilities cannot be implement the CVR method, because if the utility decreases the supply voltage for all appliances then energy losses occur because some of the home appliances have constant power characteristic. So CVR method is very effective when it is implement to constant resistive load and constant current load. Therefore for optimized implementation of CVR method, the efficiency of CVR over different appliances need to be identified.

The methods to quantify the CVR effects and efficiency are given in [4]. The simulation based quantifying the CVR effects are given in [5] and [6]. In [7], Mathematical static model of electrical load is given to test the CVR effects on it. Local voltage control method for CVR is given in [8]. The local voltage method provides the facility to implement the CVR at consumer premises. Signal processing and control method for CVR is given in [9]. In [10], [11], the CVR implementation method and planning and are given for CVR control at feeder or at substations by utility. Modeling, measurement and verification for a CVR installed substation with real time data is given in [12]. From all the above research and reviews, efficiency of CVR is not tested at consumer premises or with local voltage control method. So in this paper the authors conducted an experiment for measuring the efficiency of the CVR method over commonly using home appliances, the experiment is conducted in machines lab at VIT University, Vellore. A smart plug design is given in [13] to minimize the standby power loss. The modified smart plug design is given in this paper for future implementation of CVR method with in consumer premises. This paper is organized as follows. In Section 2, Description of Experimental setup. In section 3 CVR implementation process with Smart plug. Conclusion is given in section 4.

2. Description of Experimental setup

Power consumption by CVR method is not applicable for all electric home appliances. For this reason, the authors conducted an experiment to test the effects of CVR under different home appliances. The authors used a latest pre-installed digital measuring table in machine lab at VIT University, Vellore is used for this experiment on CVR. The testing table contains digitalized AC power sensor, AC voltage sensor, AC Current sensor, with auto transformer and Digital output. The controllable AC source voltage to the appliances is supplied by an autotransformer. The power sensor is connected between source and load to measure the power. The voltage sensor is connected across the autotransformer to measure the input supply. The testing table with appliance is shown in Fig. 1. To test the benefits of CVR with respect to different home appliances, initially the appliances are supplied with 230v. The power consumption with supply voltage of 230v is measured. Then the same appliances is operated with supply voltage of 200v. And the power consumption for 200v is measured. Same like this the experiment was conducted with some home appliances which is commonly used. Table 1 shows the power consumption of different home appliances with 230v and 200v supply voltage. From the table, the power consumption for most of the home appliances reduced by VRM. Power consumption for PC desktop, TV, Induction Stove, PC monitor and lighting are not changed by VRM. This type of appliances belongs to constant power characteristics. This experiment show the VRM reduces the power consumption for about 64% of electric home appliances. In Fig. 2. Shows the power consumption with respect to time for Induction Stove, Iron, Electric Cooker, and Microwave Oven. In this figure,